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**Evaluation of the MC-300A Soil Moisture
Meter to Determine In-Place Moisture
Content of Refuse at Land Disposal Sites**

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EVALUATION
OF THE MC-800A SOIL MOISTURE METER
TO DETERMINE IN-PLACE MOISTURE CONTENT
OF REFUSE AT LAND DISPOSAL SITE

Progress Report

A Division of Research and Development
Open-File Report
written by
Richard J. Wigh, Engineer

U.S. ENVIRONMENTAL PROTECTION AGENCY
Solid Waste Management Office

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ABSTRACT

This report presents the results of a laboratory investigation of a portable soil moisture meter (MC-300A)* for the determination of in-place moisture of refuse.

The laboratory investigation consisted of preparing several samples of fresh and composted refuse at varying moisture contents. Moisture meter probes were inserted into the refuse samples and meter readings obtained. Calibration curves relating moisture content to meter readings were then drawn.

The preliminary results of this investigative effort indicate that the usefulness of the instrument is probably limited only to noting changes in moisture rather than specific changes in moisture content. Also, the decomposition of the refuse with time could further limit the usefulness of the equipment.

*Mention of commercial products does not imply endorsement by the U.S. Government.

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EVALUATION OF EQUIPMENT FOR
DETERMINATION OF IN-PLACE MOISTURE
CONTENT OF REFUSE AT LAND DISPOSAL SITES

INTRODUCTION

The moisture content of solid waste materials at land disposal sites influences the rate of decomposition of the solid waste and the subsequent gas and heat production.¹ There are also indications that the moisture content of the materials can influence the dry density that can be achieved by compaction in a manner similar to the moisture-density relationship of soils. The changing moisture content can also be used to determine the effectiveness of a soil cover to prevent moisture movement into the waste and to evaluate moisture routing theories^{2, 3} for predicting the amount and timing of water movement out of a fill. Additional interest in the moisture content of landfills could develop if refuse materials should be used for the disposal of liquids and sludges as a storage and treatment media.

A method for determining the moisture content of solid waste materials is available,⁴ however, this oven drying procedure

requires the use of a sample of the material. This makes field measurement somewhat difficult and would involve the retrieval of actual samples from the location desired. This is especially critical in research efforts where boring or other efforts to obtain a sample could possibly disturb other study efforts.

In planning the Division of Research and Development's field land disposal research facility, the need for a moisture measurement method was envisioned and a study was initiated to select an appropriate method. This report presents the results of some preliminary work in the evaluation of the selected instrument.

INSTRUMENT SELECTION

Planned experiments at the field land disposal research facility required a method of moisture measurement or an instrument that would hopefully meet the following basic requirements:

1. Capability of monitoring from depths of as much as 50 feet
2. Simple construction and operation
3. Durable
4. Portable
5. Relatively inexpensive

6. Simple calibration

7. Continuous monitoring capability

Accuracy was also considered, but due to the field usage and the heterogeneous nature of the refuse materials, within $\pm 20\%$ of the actual moisture content was considered sufficient.

Three pieces of equipment were considered for use. These were the agricultural gypsum block, the electrically operated fiberglass moisture cells and meter, and a nuclear moisture meter.

The nuclear moisture-depth meters (neutron scattering technique) fail to meet many of the requirements established for the experiments. They also require either access tubes into the fill so the neutron source can be lowered to various depths, or establishment of multiple nuclear sources throughout the fill. Given the expense of purchasing this equipment and the possible loss of radioactive sources in the fill, this alternative was not seriously considered.

The gypsum block and the fiberglass cell operate very similarly, both providing a readout of electrical resistance as relates to the moisture content of the probe. Of the two probes, the fiberglass cell was considered to be more accurate and also gave a

reading of temperature on the same meter so that the moisture content resistance reading could be corrected. The readout meter was a small battery-operated model easily carried by hand. Cost of the meter was approximately \$210 and the individual cells cost approximately \$10 each, the price depending upon the length of the lead wires.

EXPERIMENTAL PROGRAM

Some efforts have been made in the past to utilize the fiberglas cells ^{1, 5, 6} and the nuclear moisture meter, ⁷ however, very little information is available on the method of calibration or the success during field usage. Personal communication with Mr. Ralph Stone indicated a general lack of success with the fiberglas cells and Dr. A. A. Fungaroli of Drexel reports very erratic results with the nuclear meter. Additional work with fiberglas and asbestos cells has been conducted at the University of Wisconsin, however, difficulties were encountered in measuring the high moisture contents. A description of the calibration procedure used at the University of Wisconsin is available.⁵

The largest drawback to the use of fiberglas cells is the extensive calibration required before field usage. The instrument is

normally used for agricultural and soils work, and even in these applications, calibration is required for each specific soil type and for each probe.⁸ This makes the heterogeneous nature of the refuse especially important in transfer of the equipment and placement from the lab to the field.

In considering this application on comparison to its usage in soils, one additional question arose. This consideration was that of the effect of the changing characteristics of the refuse with time. Although there is little data available on the time variance of moisture properties of refuse,⁶ it was suspected that the field capacity of the refuse would change with decomposition. Thus, fiberglas cells calibrated in fresh refuse and placed in similar material in the field might not be reliable but for a short period of time. This would have to be compensated for by burying new probes. The new probes would have to be calibrated in refuse at various stages of decomposition which is no simple task.

One possible alternative that might avoid this problem would be calibration in a uniform and nondecomposing material. This could be soil surrounded by refuse through which the water is allowed to move to compensate for the varying conductivity of

the water. Calibration in this manner, however, creates a different problem when one considers the different moisture storage properties of soil and refuse. The measurement of a moisture content in the soil might not be at all indicative of that in the refuse due to these capillary and hygroscopic properties. Hopefully, this could be compensated for in the calibration.

Use of an alternative such as the soil-refuse combination might not entirely remove the problem of the decomposing refuse and changing moisture properties, and since it does introduce the additional consideration due to different moisture properties, it was felt that initial tests should be conducted with refuse only. Refuse that was fresh, some that had been buried three months, and composted refuse from Johnson City, Tennessee, was used to determine the effect of decomposition.

Laboratory tests were conducted during the summer of 1969. A detailed outline of the calibration procedure appears in the appendices. No attempt was made to quantitatively measure the stage of decomposition of the materials.

TEST RESULTS AND DISCUSSIONS

The data obtained from the limited number of tests is shown in Table I.

Figure I shows the calibration curves obtained using fresh refuse and 3-month old refuse. Considering the curve for the fresh refuse with the 10' lead, the high range of moisture content over the relatively narrow range of resistance is quite alarming. A corrected reading of 4×10^3 ohms would indicate a dry weight moisture content of 158%, and a corrected reading of 3×10^3 ohms would give 225%. A slight error in reading or temperature correction could lead to a rather large error in moisture content. Equally alarming is the comparison of the two calibration curves for the fresh refuse. Although there is some difference in lead and probe resistance, the vertical and horizontal separation of the curves is quite large. This seems to indicate a large effect due to heterogeneity of the refuse (both probes were buried in the same sample) in some moisture ranges and that field usage might not be at all representative of lab conditions. For example, a corrected probe reading of 10^4 ohms would mean a dry moisture content of either 40% or 140% for the fresh refuse. No comparisons can be made in the high moisture portions

of the fresh refuse curves because of the failure to obtain the data with both leads and probes.

The two curves for 3-month old refuse do not show as large a variance between each other, but what is notable is the difference between these curves and those for the fresh refuse. A corrected reading of 10^3 ohms shows a moisture content of 47% or 77% for the 3-month old refuse, yet a moisture content of 335% was obtained for the fresh refuse. Much of this could be due to material heterogeneity since maximum moisture in the fresh refuse was 342% and in the older material only 77%. Some of the difference, though, is probably related to the varying moisture holding properties with decomposition. This moisture holding difference is substantiated further by tests with compost where upper moisture contents (field capacity) varied from 113% to 192% which is far less than the 342% for the fresh material.

Figure II shows the curves obtained using the same probe on three different samples of composted refuse. It is not felt that the first curve (—●—●—) is too meaningful because of errors in sample preparation. The other two curves are on compost of different ages and are somewhat similar. Disturbing, though, is the fact that for different moisture contents the same corrected resistance was obtained.

CONCLUSIONS

Although the investigation is incomplete at this time, the discrepancies noted so far indicate that the instrument being used is far less accurate than first thought. Its usefulness is probably limited only to noting changes in moisture rather than specific changes in moisture contents. This could still be useful in studying movement of moisture fronts, but not necessarily in correlating moisture content and gas production or temperature.

The problem of changing moisture properties with time due to decomposition is probably serious enough to further limit the usefulness of the equipment. If the probes are to be placed directly in refuse in the field, the data should be considered qualitative and little confidence should be placed in the quantitative measurements.

RECOMMENDATIONS

Further tests should be conducted to investigate the effects of heterogeneity and moisture changes due to decomposition and to more clearly define the limitations. Tests should include the development of curves over two or more drying cycles. All

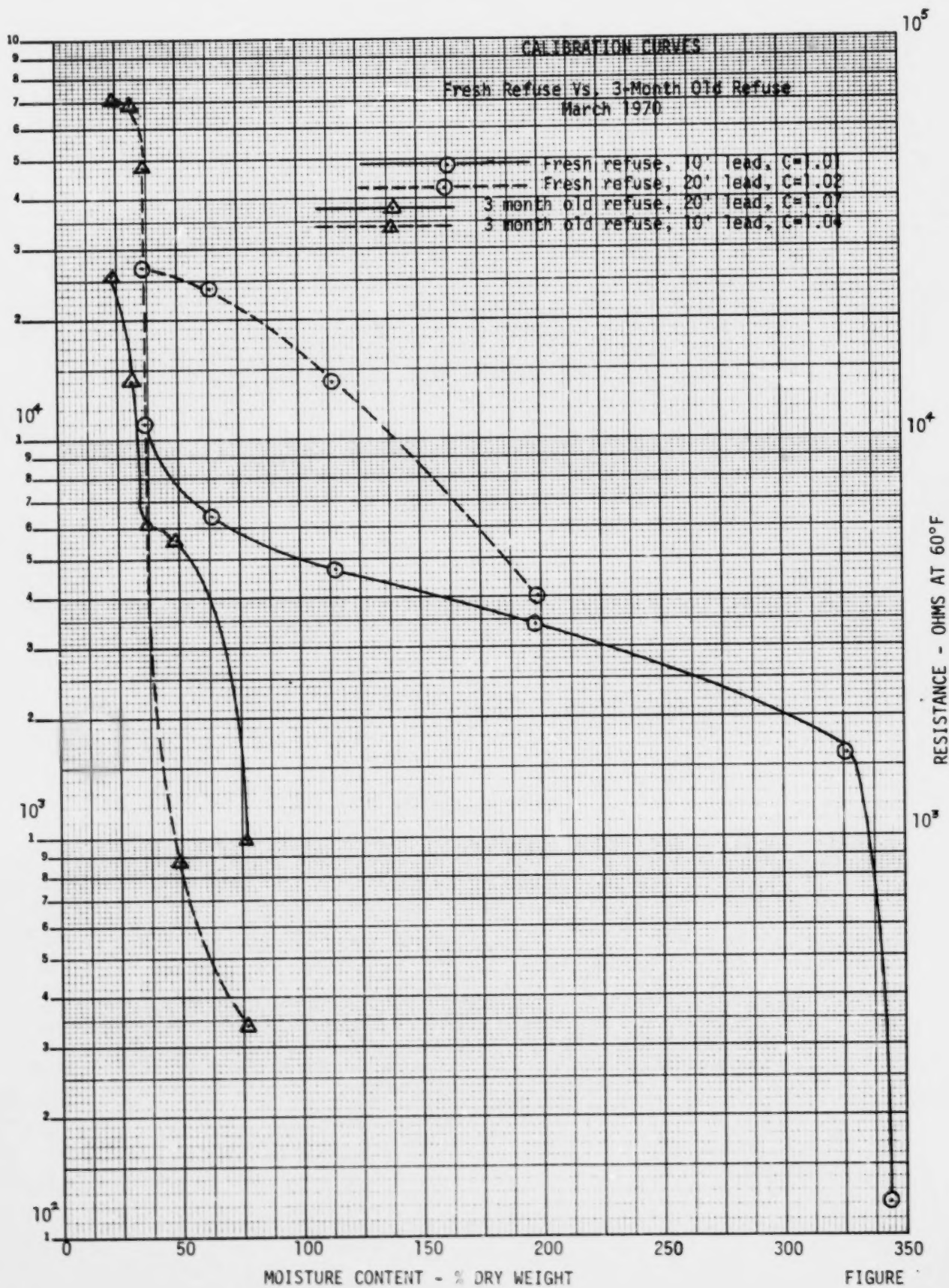
glass, metals, rocks, plastics, rubber, and ceramics should be removed to lessen the effects of heterogeneous materials.

Tests should also be expanded to include soil surrounded by refuse to try to improve reliability and quantitative capability.

Future investigations in relation to this equipment should consider the phenomena of changing field capacity in order to define limits of moisture retention.

REFERENCES

1. Merz, R. C., and Stone, R. Factors Controlling Utilization of Sanitary Landfill Sites, Final Report to the Department of Health, Education, and Welfare, Project No. EF-00160-03, 126 p., July 1963.
2. Remson, I., et al. Water Movement in an Unsaturated Sanitary Landfill, JSED, ASCE, Volume 94, No. SA2, April 1968, pp. 307-317.
3. California State Water Pollution Control Board, Effects of Refuse Dumps on Ground Water Quality, Publication No. 24, Sacramento, 1961, 107 p.
4. American Public Works Association, Municipal Refuse Disposal, 1st ed., Chicago, Public Administration Service.
5. City of Madison, Wisconsin and the University of Wisconsin, Third Progress Report, City of Madison Demonstration Grant 1-D01-UI-0004, March 1969, unpublished.
6. California State Water Quality Control Board, In-Situ Investigation of Movements of Gases Produced from Decomposing Refuse, Publication No. 31, 1964.
7. Drexel Institute of Technology, Research Grant Reports.
8. Colman, E. A. Instruction Manual, MC-300A Soil Moisture Meter and Cells, Soiltest, Inc., Bulletin C172-64, 1964.



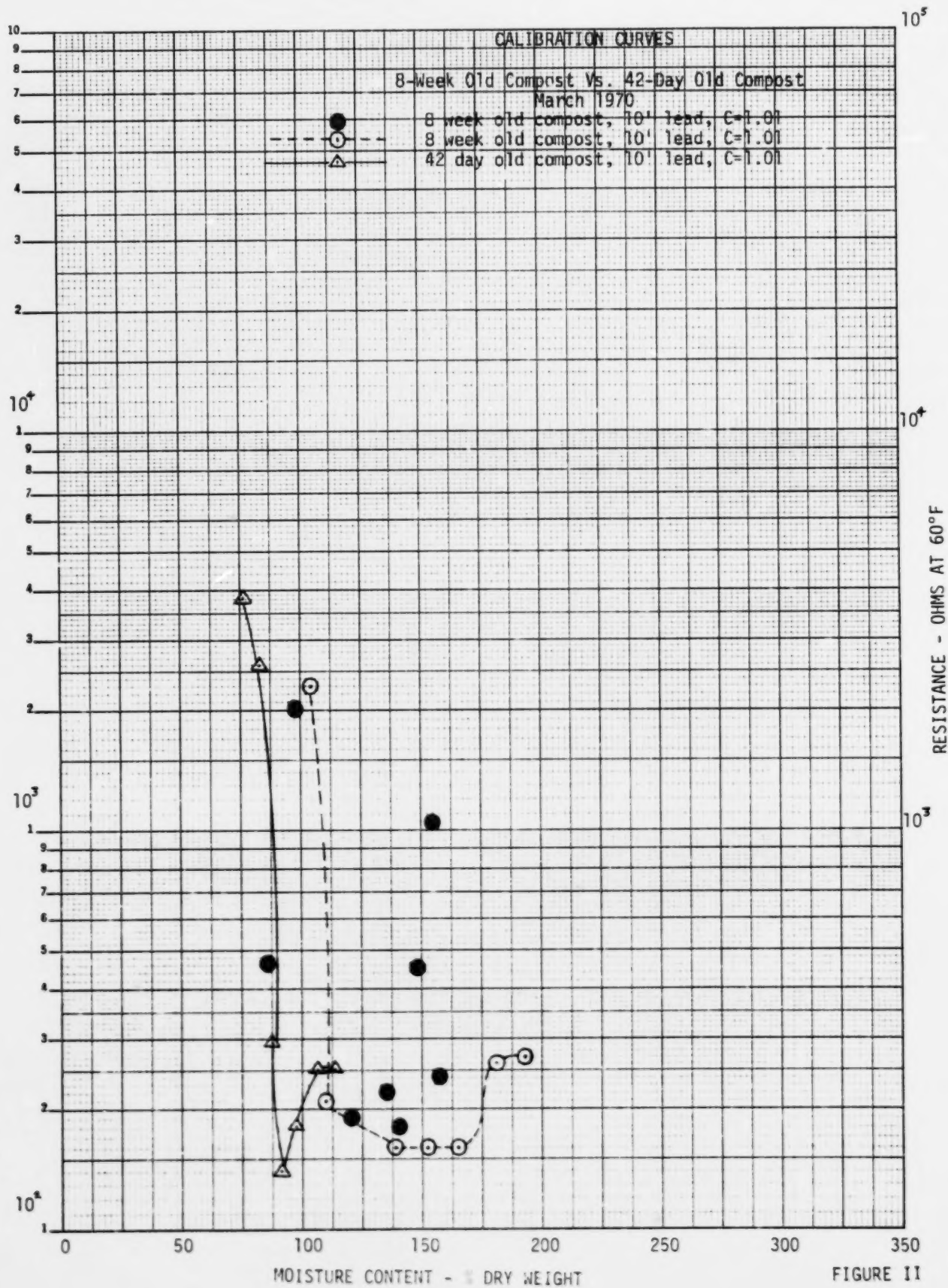


TABLE I
EVALUATION DATA

Sample	Probe (length & constant)	% Moisture (dry weight)	Meter Reading (average)	Range	Corrected Resistance (ohms @ 60°F)
F (3-month old refuse)	20' 1.07	76.7	184.5	Low	3.4×10^2
		48.2	159.3	Low	8.8×10^4
		36.8	120.0	High	4.4×10^4
		31.2	91.8	High	6.9×10^4
		23.0	94.7	High	7.0×10^4
F (3-month old refuse)	10' 1.04	76.7	155.7	Low	1.0×10^3
		48.2	92.7	Low	5.6×10^3
		36.8	83.0	Low	6.1×10^3
		31.2	54.8	Low	1.4×10^4
		30.0	152.8	High	2.6×10^4
E (fresh refuse)	10' 1.01	342.7	194.8	Low	1.2×10^2
		326.4	142.0	Low	1.6×10^3
		197.8	116.5	Low	3.4×10^3
		114.6	93.5	Low	4.7×10^3
		63.6	83.0	Low	6.4×10^4
		36.9	60.0	Low	1.1×10^4
E (fresh refuse)	20' 1.02	197.8	103.7	Low	4.0×10^3
		114.6	187.8	High	1.4×10^4
		63.6	159.7	High	2.4×10^4
		36.9	153.5	High	2.7×10^4
B (8-week old compost)	10' 1.01	154.6	158	Low	1.05×10^3
		153.6	190	Low	2.4×10^2
		148.7	180	Low	4.5×10^2
		139.9	193	Low	1.8×10^2
		134.6	191	Low	2.2×10^2
		120.7	193	Low	1.9×10^2
		97.4	137	Low	2.0×10^3
		86.0	179	Low	4.6×10^2
C (8-week old compost)	10' 1.01	192.4	187	Low	2.7×10^2
		180.1	189	Low	2.6×10^2
		164.2	194	Low	1.6×10^2
		151.8	194	Low	1.6×10^2
		137.9	194	Low	1.6×10^2
		109.6	191	Low	2.1×10^3
		103.8	131	Low	2.3×10^3
D (42-day old compost)	10' 1.01	112.7	189	Low	2.5×10^2
		106.3	190	Low	2.5×10^2
		96.9	193	Low	1.8×10^2
		93.0	195	Low	1.4×10^2
		87.2	187	Low	2.9×10^3
		82.7	124	Low	2.6×10^3
		76.0	107	Low	3.8×10^3

APPENDIX

OUTLINE OF CALIBRATION PROCEDURE

Preparation of Sample

1. Dry out sample of approximately 500 grams of refuse at 70°C until workable enough to cut into approximately 1" square chunks. Remove all metal and break up glass chunks.
2. Replace sample in oven at 70°C, dry for 12 hours, let cool in dessicator. Transfer to plastic perforated sheet (24" x 30"), tie with wire to form a bag, and weigh. Subtract weight of sheet and wire to obtain dry weight of sample.

Saturation of Sample

1. Suspend bag over 1-gallon jug containing 2000 ml distilled water, open bag, and pour additional 600 ml directly over and around bag. Force bag into water as much as possible (will tend to float). Spread edges of bag over lip of jug, screw on top, and label jug. Allow water to soak in over night.
2. After soak, water should be standing in bag. Pour out most of water in jug and suspend bag over the water in the jug. Water should drip out of holes in bag, but if drainage is slow, the bag can be squeezed lightly to force water out. Allow drainage until there is no more standing water and the bag no longer drips water.

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Permeation

1. After bag is drained, open it up, place bag on a No. 4 sieve so that any excessive water can drip through. Place probes in sample, fold the bag around the probes, and pile the remainder of the leads onto the bag. Then put the sieve, bag, and leads into a glass dessicator with 1-2" of water in bottom. Allow the sample to permeate within the dessicator over night. If possible, extend the leads out of the dessicator so that readings can be taken without removing the lid.

After preparation, readings with the meter were taken according to the following procedure:

Readings

1. After night permeation, take readings the following morning. Monitor each lead for at least 60 minutes to assure a constant reading. Then hook up a particular lead and take six readings at 2-minute intervals. This many readings should make up for any mistaken readings or other errors involved. Record readings (and range) on data sheet (temperature always low range).

2. After all leads are completed for a particular sample, take the bag from the dessicator, remove the probes, tie the bag up with the wire, and weigh. Record weights, determine amount of water present in sample, and divide this number by the dry weight of sample. This gives the % moisture.

3. This procedure was repeated at varying time intervals to allow drying of the sample to obtain different moisture contents.